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DISEASE PREVENTION

REHABILITATION

and

ATMOSPHERIC POLLUTION

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COVER PLATE

The photograph on the cover, by Malak, illustrates an advanced stage of automation in a hydro-electric power installation.

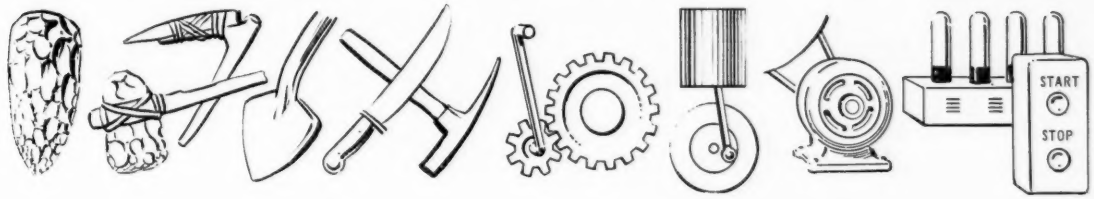
OMISSION

In the July 1957 issue of the Review, the article, Carbon Tetrachloride—An Underrated Hazard, was printed under the sole authorship of Dr. Guy Joron. There were also two other co-authors, Drs. Charles H. Hollenberg and E. H. Bensley, whose names did not appear. The Division wishes to apologize for this oversight.

EDITOR'S NOTE

The date of issue of this Review was December instead of October because of the dislocation due to the Division's recent move from the Jackson Building to 45 Spencer Street. Regular quarterly publication will resume as per schedule with Volume 10, No. 1, April 1958.

AUTOMATION AND OCCUPATIONAL HEALTH



by A. V. Raison, B.A.,
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Since the beginning of time, society has always been in a state of flux, ever changing, as man has striven to improve his lot, and make his existence less arduous. Some of the changes have come about very slowly, others more abruptly. Such has been the case in the development of industry over the centuries. At first, man created his products, using his bare hands, or at the best, crude tools which he, himself, had fashioned through necessity, curiosity or resourcefulness.

This situation was slow to improve but gradually over the centuries, tools replaced bare hands, and individual enterprise became organized into group effort. But still the man was master of the tool and could be justifiably proud of personal accomplishment and team effort.

Man has always been resistant to any drastic change, especially when he thought it might undermine or otherwise affect his own security or means of livelihood, and particularly if he did not understand the underlying reasons for it. One event which created perhaps the greatest impact on man and his way of life was the introduction of mechanization during the Industrial Revolution in England. At first this change was viewed with fear and bitterness because workers felt that their security was threatened. They even resorted to violence in certain instances in an attempt to halt the progress of mechanization. But as history has proven the machine age opened up avenues of opportunity hitherto undreamed of.

Mechanization, while creating an unprecedented increase in production, nonetheless introduced a variety of new hazards to workmen not previously encountered. Among these were the hazard of accidents from unguarded machines, fatigue and boredom from repetitive work predisposing to carelessness with increasing possibility of accidents, exposure to poisonous fumes, gases, etc., from the use of new chemicals in processes without proper ventilation, or other environmental control, exposure to excess noise from machinery, lack of organized accident prevention programs, inadequate health facilities and numerous other factors.

However, over the past half century, there has been a vast improvement in the working situation; today, atmospheric contaminants can be well controlled; the harmful properties of materials used in manufacture can be predetermined by biological research; control and safety features are incorporated into machine design; ventilation and air-conditioning systems can prevent undue exposure to dangerous gases, fumes, etc. and provide the workers with a pleasant work atmosphere; noise and radiant energy are reasonably well controlled; and protective clothing and equipment are available to safeguard the worker from hazards which cannot be completely eliminated by other measures.

Automation

Despite all of these improvements, there still remains the human factor to account for. Controls on machines and protective equipment are of no use if not employed; and health education is of little value if not carried over to the home and family.

Recently there has been a trend towards automatic control of machinery to eliminate human failure, and this new development is identified by the newly coined word, automation. Automation has been given various definitions from the elimination of human direction and hand operation on the assembly line to the automatic control of machines by other machines. It is more than just an advancement in mechanization; it introduces an entirely new concept. In mechanization, man and the machine functioned together; in automation, man controls and supervises the machine, but has no part in the actual operation of it.

Automation is certain to have a profound effect on society. It will necessitate changes in working habits, alterations in our educational systems, reorientation of policies in relation to job analysis and placement and

many other adjustments in our way of life, but once having been successfully put into effect it should raise our standards of living to new heights.

Implications of Automation

In mechanization man had to pace himself to the rhythm of the machine — a rhythm to which he may not have been able to adapt readily without undue effort. This situation sometimes produced fatigue and tension, factors which could predispose to reduced efficiency and accidents. Automation, by obviating the need for human participation in machine operations will eliminate these potential hazards.

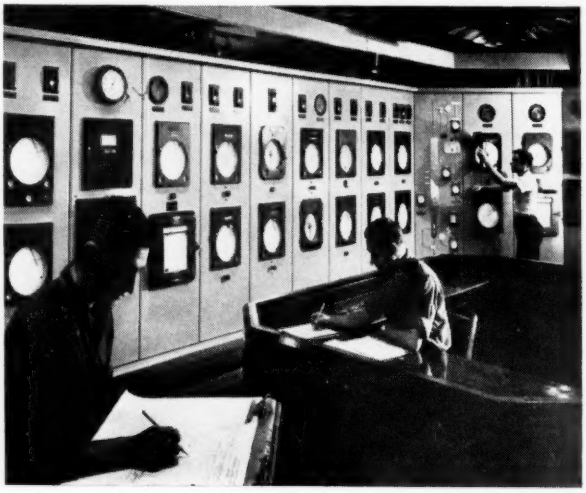
Automation will greatly reduce the need for some of man's sensory apparatus formerly so important in machine operations and inspection of materials and thus will eliminate errors in perception, which result from mental stress, fatigue, negligence and other factors. Also with closed systems, there will be little chance of exposure to poisonous gases, fumes, etc. except perhaps from ruptures in lines or acute exposure during maintenance. Factors such as ventilation, humidity, temperature and noise will no longer interfere with work performance.

Automation, by eliminating contact between the man and the materials used, makes possible the use of substances formerly too toxic for safe handling (particularly radioactive materials, very poisonous chemicals, etc.).

(Photo by Malak)

Fig. 1 The hoist eliminates manual lifting and handling of heavy loads.

Manual operations formerly involved in loading, unloading, and transporting of heavy materials will be eliminated, and there will be little danger of strains, hernias, dislocations, back injuries, or other injuries, such as broken bones, crushed feet, etc.; and there will be no chance of catching the fingers in the moving parts of machines.



(Photo by Malak)

Fig. 2 An example of simple control of complex operations.

New Problems

Automation introduces some very important new problems, which will require special consideration.

The actual operation of automatic machines may not necessitate much additional technical training although operators will need to understand their machines, and the principles of operation. It is suggested that new operative skills may be acquired through training on the job. However, engineers, maintenance personnel, supervisory and managerial staff will require a much higher level of education to be able to maintain and service complex machines, cope with production problems and maintain an intelligent and satisfactory cooperation in the total effort.

Then, too, there will be a considerable increase in capital investment per employee. In U.S.A., in the highly automatized electric power generation industry, the present investment per employee is said to be in excess of $106,000.

In order to maintain employment at a high level, working hours will be shortened, thus increasing the leisure time. This can create a problem of boredom for those whose avocational interests are limited, and contribute to an increase in home accidents from do-it-yourself jobs. In many cases the do-it-yourself "expert" is doing work for which he is not trained, with tools he does not know how to use and is unaware of the associated accident hazards. Another consequence of increased leisure time is the practice of taking on a second job, commonly called "moonlighting." There are divided opinions on this practice; some authorities feel that it is not advisable; others see no particular objection to it.

It would seem reasonable to assume that if an individual has few hobbies and has no particular interest outside of his work, a part-time job might create no serious effects, provided that it does not interfere with his regular job, cause lack of sleep or place extra strain on faculties normally employed during the day. Increased leisure may also promote more travel, with the greater possibility of more highway accidents.

These are only a few of the factors to be anticipated when planning industrial automation and they will have a profound effect on the health and general well-being of the worker, who is industry's most valuable asset, despite changing methods of manufacture.

The Importance of Health Maintenance in Automation

The increased capital investment per employee will mean that automatized industry will have an even higher stake in health maintenance. Illness or accident will not only interrupt production if the employee is absent but will also result in a loss of efficiency if he is functioning below par on the job (particularly in operations requiring constant vigilance). This will represent a much greater economic loss because of the broadened scope of each worker's activity.

Current Systems of Health Maintenance

Most larger, and a number of smaller, industries provide health services for employees at the work place on an in-plant basis, employing a doctor and/or nurse or nurses on a full-time, part-time or on-call basis. The scope of these services varies according to the type of work, number of employees, age and sex of employees and other related factors. The average service provides preplacement, periodic and special medical examinations, first aid and emergency treatment of illness and injury, health education and counselling, home visiting by the nurse (in some instances), periodic inspection of plant operations and other functions including co-operation on safety committees, liaison with hospital and other community health and welfare organizations. It has been demonstrated quite conclusively that provision of health services at the place of work is a practical means of ensuring good health maintenance to large segments of our adult population.

Changing Concepts in Health Maintenance

Automation will necessitate a reorientation of approach to health maintenance. Since the hazard of injury or disease will be practically eliminated, the treatment aspects of the health program will be greatly reduced. However, this does not mean that they be overlooked because there will still exist the possibility of severe exposure to dangerous substances due to line ruptures or leakages, or where maintenance work is involved. Such situations will require special and immediate treatment and the medical officer and nurse must be familiar with the toxic properties of the offending substances, and the most effective means of treatment. Coincident with the reduction in physical problems, there may be an increase in mental problems, caused by increased responsibility, displacement, and other anxiety producing situations. This will require the industrial medical personnel to have in addition to medical qualifications, a thorough understanding of psychiatry, sociology, human engineering (matching the man to the machine) and industrial hygiene.

The modern concept of preventive medicine, that is the total physical and mental well-being of the worker both on and off the job, will be more important than ever in automatized industry. Over the past few years, the number of work accidents has decreased and as automation progresses, an even greater reduction can be expected, but there is still the off-the-job accidents to be considered. It is estimated that these account for *90%* of absenteeism, a point which should justify the company's around-the-clock concern with the worker's health.

In the field of industrial toxicology, there will be a shift in emphasis from the simple determination of lethal doses and description of injury to investigation of the manner in which the injury affects the health and well being of the individual — in short, preventive industrial toxicology. The industrial physician, to be most effective, must keep himself informed on new chemicals and other substances introduced in industry and the health hazards associated with them.

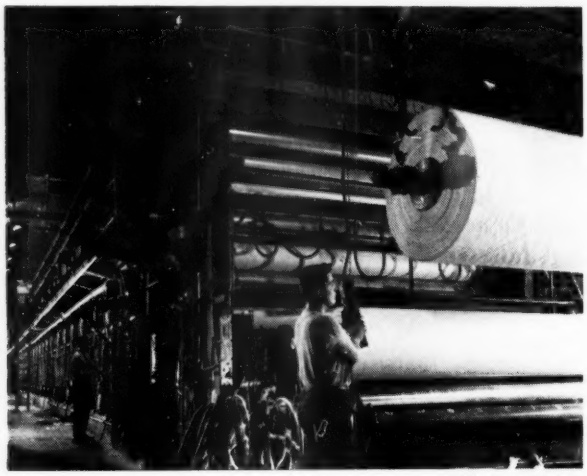
Changes in The Health Services Program

As mentioned previously there will be a shift in emphasis from treatment of injuries and diseases to psychiatry, health counselling and selective placement through evaluation of the prospective employee's physical and mental status.

The Preplacement Examination — In selective placement, physical strength will be of secondary importance. The physician will be required to know the physiological and environmental conditions to be encountered during operation of the machine as well as the physical requirements, such as the sense organs involved, and the perceptual requirements, the over-all movements necessary for operation and the speed and accuracy necessary for operations of the machine. In fact, it is predicted that eventually a detailed capability analysis will be part of the regular preplacement examination.

The Periodic Examination — As automation advances the hazards of accidents, injury and disease will gradually diminish and the former emphasis on

physiological and environmental problems will be shifted more and more to the relationship between work and the stress disorders. The effects of stress on health have recently come under study, but up to now, the greatest incidence of stress disorders, such as heart trouble, high blood pressure, and ulcers, has been among executives. But with advances in automation, there will be a great increase in the number of skilled and professional personnel, and the average worker will be required to qualify for up grading to more technical jobs such as maintenance and repair of machinery, and other complicated work, which may prove to be a strain. The periodic examination will provide the industrial physician with valuable information on the degree of occupational stress introduced by automation. In this way he can keep up-to-date on changing health problems and extend his program of preventive medicine still further.



(Photo by Malak)

Fig. 3 With automatic control physical strength is of secondary importance.

Health Counselling and Education — This aspect of the health program has always been very important in industry, and particularly to the promotion of preventive medicine and safety. With automation, and the anticipated shorter work week, there will be an increase in leisure time and thus a greater chance of an increase in health problems of non-occupational origin. Health education and advice can be extended to include health maintenance in the home as well as on the job. Information on such topics as home safety, nutrition, sanitation, etc., should be made available and the health staff should be prepared to help the employee with any off-the-job problem which might interfere with his efficiency or satisfaction with his job.

Medical schools and other educational organizations will need to direct increased attention to training of personnel to cope with the emerging health problems introduced by automation, and administration of preventive medical programs of health maintenance in industry.

Human Engineering — Matching the man to the machine will be of major importance in automation and will necessitate knowledge of, and careful investigation into, the relationship between the man and the machine. The physician and the design engineer will need to cooperate very closely in order to ensure the most efficient and beneficial use of human abilities and capacities. Work facilities and working environments should be designed and organized in such a way that stress and strain producing situations are minimized; and frequent observation of work situations will be necessary to reveal placement inadequacies and allow solution of the problems before any serious difficulties arise. Boredom and fatigue can result from a wide variety of stresses, both physical and mental, and if the situation is not improved, the result may be very costly both to the man and the company concerned.

Summary and Conclusions

An attempt has been made to anticipate the impact of automation on industry and the labour force, with particular reference to health implications. From past experience, any radical change in industrial experience will not take place overnight, although with the present acceleration of industrial development it may be comparatively much faster than has formerly been the case. As with any new development, there is certain to be some dislocation of the labour force but with attention to such factors as adequate education, retraining, proper preplacement and preventing or resolving emerging health problems, through preventive medicine and human engineering, automation will make possible an even greater enjoyment of life, a safer and healthier working place and a prosperity far beyond anything encountered in the history of mankind.

Automation is synonymous with industrial progress, the evolution and momentum of which are entirely dependent on continual change. The necessity for constant change is aptly illustrated in the following statement by Thomas Carlyle:

Today is not yesterday. We ourselves change. How can our work and thoughts, if they are always to be the fittest continue always the same? Change, indeed, is painful yet ever needful; and if memory has its force and worth, so also has hope.

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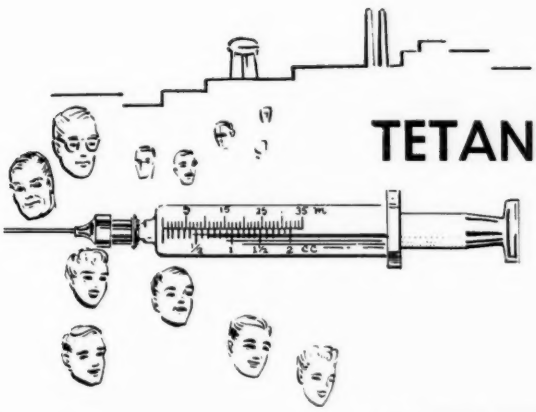

TETANUS PROPHYLAXIS– A REVIEW

by A. J. de Villiers, M.R.C.S., L.R.C.P., D.I.H.
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One of the principle advantages of active immunization against tetanus by the administration of toxoid is that it eliminates very largely the need for antitetanus serum.

The effectiveness of toxoid in producing a safer and a much greater degree of protection has been amply and irrefutably illustrated by the experience of the armed forces during World War II. Many of the veterans and particularly those who have received toxoid in the armed forces since then still retain an effective immunity. Together with these the increasing number of children receiving protection in the form of combined vaccines, daily swell the total of the immunized among the general population.

The risk of tetanus is, however, still a significant one when the large majority of the adult population is considered. Further, the risk of tetanus in any future war would probably not be restricted to military personnel and this most certainly would indicate the importance of widespread active immunization of as large a proportion of the population as possible.

Industry, representing smaller and eminently more easily controllable population groups from the point of view of immunization programmes, could make an important contribution. In addition, active immunization would be made available to and provide protection for those people who by nature of their employment may be exposed to a higher incidence of the disease, either because of the greater risk of injury involved and/or involving a particularly tetanus-prone terrain.

A great deal has been written concerning tetanus prophylaxis but there is still considerable diversity in its actual practice. It is with this in view that some of the more important aspects related to the problem are being reviewed here. As Cole stated: "even limited application of active immunization on these lines would undoubtedly do more to eliminate tetanus than anything else".

Tetanus is a typical example of a *pure toxemia*, the clinical manifestations of which are due to the stable bond formed between the cells of the brain and spinal cord of susceptible hosts and the tremendously powerful toxin produced by clostridium tetani organisms, usually at a distant focus of infection in the body. It is well-known that the organisms normally inhabit the intestinal tract of horses, other animals, and man, the organisms are of an anaerobic nature and the spores may remain viable for very long periods. The organisms and spores are therefore universally present in man's environment and constitute a potential source of contamination to all wounds.

The *incubation period* is directly related to the severity of the disease. It varies greatly, ranging from 3 days in fulminating cases to 90 days in others with an average of 10-14 days. The average period in non-immunized individuals who have not received antitetanus serum is 12.8 days (48). The introduction of passive immunity during the 1914-18 war apparently affected the incubation period, shifting the peak to after the 35th day (59). During the 1939-45 war however, with active immunization generally practised, the average incubation period of cases amongst the British and American wounded was found to be 9.6 days (9) and much longer in those cases which also received anti-toxin serum.

The *incidence* of clinical tetanus is highest amongst the early and middle age groups, 30-50 years (62), more common amongst males, probably because of their employment, more common and more severe in the tropics and in highly cultivated areas.

The associated *case mortality rate* has been variously estimated at between 20 per cent and 77 per cent (26). This last mentioned mortality rate has, however, no real meaning in the light of modern treatment. The death rate is highest at the extremes of life (62), higher in males (41, 17), higher amongst non-whites (9) and higher in rural areas (17). At least 90 per cent of all fatalities occur during the first ten days of illness (63).

The *prognosis* of tetanus is usually based on the length of the incubation period and the interval between the appearance of the first symptoms and generalized spasms ("period of onset") (15). If the incubation period is less than one week or the period of onset less than 48 hours the prognosis is regarded as poor. Considerable improvement in the prognosis has been brought about by modern methods of treatment such as sedation, chemotherapy for the treatment of complications (65 per cent to 35.4 per cent reduction in mortality rate) (62), muscle relaxant drugs, tracheotomy and assisted respiration. Much of this improvement in prognosis therefore depends on early effective treatment and the sustained and concerted efforts of a "tetanus team" which would combine the specialities of internal medicine, surgery, anaesthesia, physiology, etc. This approach has been successful in reducing the mortality rate at the Mayo clinic from 52 per cent (66 cases) to 27 per cent (26 cases.) (10). The chance of survival increases after the tenth day of illness and is usually good by the fourteenth. Despite these improvements the mortality

rate in puerperal tetanus remains at between 75 and 100 per cent (1) and splanchnic tetanus in which the muscles of deglutition and respiration are chiefly involved practically always proves fatal.

The disease is, however, not followed by any lasting immunity as recurrent cases have been reported (12, 45). The only available protection against the disease at present is that provided by passively or actively induced artificial immunity and by standard surgical procedure in the care of wounds.

Passive immunization was first introduced for routine use during the 1914-18 war, and anti-tetanus serum was administered to all who were wounded. This reduced the incidence of tetanus in a few months from approximately 8 per thousand to 1 per thousand amongst the British Army during the early part of the war and later this figure was lowered still further (38).

Anti-tetanus serum produces protection which lasts for a varying period of time depending largely on the dose administered, and reaches a maximum circulating blood titre in two or three days (48). The protection provided by 1,500 units usually wears off in two to three weeks (12) although it should not be expected to last for longer than seven days in practice; 10,000 units may produce protection lasting from 6 to 10 weeks and 100,000 units from 8 to 11 weeks.

Apart from this short lasting immunity the possibility that the patient may be inherently sensitive or may have become sensitized to serum as the result of previous medical treatment constitutes the principal disadvantage of this type of protection. The most serious of these reactions is *anaphylactic shock* which comes on within 2 or 3 minutes to an hour after the serum has been given. The other well-known reactions include *serum sickness* which manifests itself on the 7th to 12th post injection day and which may simply appear as a slightly irritating red swelling at the sight of the injection, or the far more uncomfortable appearance of a severe generalized itching dermatitis and urticaria and/or painful, swollen joints. An accelerated reaction occurs more particularly in individuals who have previously received serum and appears within a few hours or a few days. Occasionally also the *Arthus phenomenon* (local anaphyllaxis) (37) follows. This is a severe reaction with swelling, induration and later sloughing of the subcutaneous or muscular tissues which may follow a supplemental dose of anti-tetanus serum when given a number of days after the initial injection. *Thermal reactions* (50) characterized by a sudden pyrexia with chills or rigor within half an hour of intravenous injection may also occur, presumably following accidental intravenous injection of serum.

Less common and perhaps also less well recognized are the potentially serious and occasionally fatal *neurological complications* of anti-tetanus serum administration. These may fall into the following main groups as discussed in a review of a hundred cases by Miller and Stanton (47).

1. *Radiculitis* (including radiculo-neuritis, mono-neuritis, plexitis, shoulder girdle neuritis) — 74 per cent.

2. *Polyneuritis*, poly-radiculoneuritis, (Guillain-Barré syndrome) (58) — 10 per cent.

3. *Myelitis* (6) and Landry's ascending paralysis — 6 per cent.

4. *Meningeal and Cerebral* (encephalomyelitic) forms (19) including optic neuritis — 10 per cent. It has been suggested that anaphylactic hypersensitivity may be the common factor in the pathogenesis of these cases.

The brachial plexus is most commonly involved (44, 47) and the usual sequence of events in this syndrome is; serum sickness; sensory disturbances initiated as a rule by severe and often intractible pain in the shoulders and appearing within a few hours to a few days after the onset of serum sickness; and motor impairment coming on within several hours to two days after the onset of pain and characterized by weakness of the affected part. Still later muscular atrophy becomes apparent. The tendon reflexes may be diminished or absent, sensory changes such as hypaesthesia and hypalgesia may occur and vasomotor and trophic changes are sometimes seen. Numbness is present in about a quarter of the cases.

Recovery of neuritic and radicular types takes place within a few months to two years and occasionally longer (61). About 20 per cent of cases are left with some residual weakness or atrophy, especially of the deltoid.

The muscles most frequently involved are those innervated by the fifth and sixth cervical segments, e.g., deltoid, spinati, serratus, biceps, and triceps. Although the phrenic nerve primarily originates from the fourth segment an explanation of its occasional involvement (with the onset of diaphragmatic paralysis and dyspnoea) (61, 16, 47) might be found in the fact that it also receives a portion of its innervation from the fifth segment. The involvement of the recurrent laryngeal and other nerves has also been described. The occurrence of this type of complication appears to have no relation to previous serum administration. The site of injection and the site of neuritis also seem to be completely unrelated.

The polyneuritic forms usually appear as frank polyneuritides and these, with the other more serious and rarer types of neurological complication, have been fully described in the available literature (20, 47, 59, 55).

Very much more rarely described are cases of *cardio-vascular involvement* during the course of serum sickness. Such involvement may include the onset of angina pectoris, periarteritis nodosa, myocardial infarction (46) carditis and evidence of transient electrocardiographic changes (68, 27).

On the whole, serum reactions are not rare and depend to some extent on the amount administered. In the early days of serum prophylaxis the incidence was reported as high as 40 to 50 per cent, but, with refinement of the sera used, it has been lowered to between 5 and 20 per cent. Moynihan (50) found an incidence of 5.29 per cent of 7,580 injections of which 2.7 per cent were localized and 2.5 per cent due to serum sickness. Two cases in this latter series suffered so-called anaphylactic shock. Anaphylactic shock has an estimated incidence of from 1 per 50,000 to 0.5 per cent and immediately fatal anaphylactic shock an incidence of approximately 1 per 100,000 (60) or between 1 per 50,000 and 1 per 200,000 (37).

The *unreliability* of the intradermal, conjunctival and scratch *sensitivity tests* has been fully discussed by Laurent and Parish (37) and was further demonstrated by the investigations of Moynihan (51) who found that injection of serum in patients with a positive skin sensitivity test gave rise to only a slightly higher percentage of reactions than the average for the whole of the group. A negative skin test on the other hand is not proof either that a serious reaction may not occur as anaphylactic shock has occurred in patients with no obvious skin sensitivity.

To obviate much of the inconvenience of the above methods and that of the usual desensitization procedure, Laurent and Parish (37) have described a "trial dose" method which Laurent himself has used successfully in everyday general practice for over twenty-five years. This method consists of a preliminary subcutaneous injection of small doses of serum which are meant to be absorbed slowly into the general circulation with a view to testing the patient's general reaction to a small dose of serum before giving him a large one. This method does not, however, ensure freedom from reactions, and will still require a long list of special precautions including detailed questioning, readily available ampules of 1:1000 solution of adrenalin, syringes, needles, a tourniquet, antihistamines, 5 per cent dextrose for intravenous use, l-arterenol, ampules of corticotrophin or hydrocortisone, a tracheotomy tray, etc.

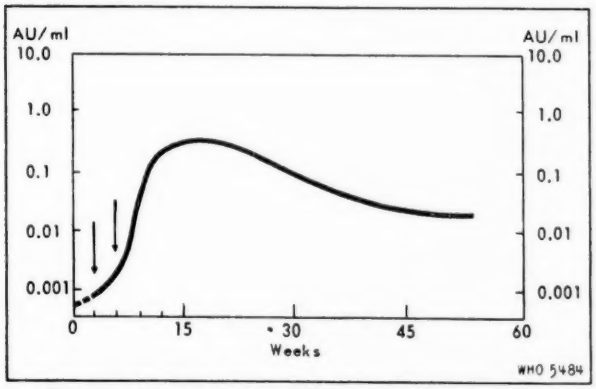
Patients receiving antiserum may not only be sensitized to further injections of horse serum but may receive *less protection with subsequent injections*. Littlewood et al (39) discuss this problem in a report on a fatal case after prophylactic tetanus antitoxin. They stated that from studies on both human beings and animals there seemed to be concordant evidence that previous experience of a soluble antigen — and horse serum — lead to a much accelerated removal from the circulating blood on a second or subsequent injection, and consequently to a curtailment of any effectiveness as passive prophylactic agents of such antigens. Kind (35) presented evidence to support this contention but he also expressed agreement with the alternative explanation of the case of Littlewood et al offered by Beeson that the conventional dose of anti-tetanus serum (1,500 units) may have been insufficient to neutralize the toxin present. Last and Nicholas (36) also described a case recently which had received more than 200,000 units of anti-tetanus serum during the initial phase of illness despite which tetanic spasm recurred on the seventeenth day.

An increase in the initial dose of anti-tetanus serum from the usual 1,500 units up to 10,000 units has been suggested. This would provide better protection in cases in which unusually large amounts of toxin were being produced and would also provide better protection in cases in which the antigen was being rapidly eliminated because of the patient's previous experience with horse serum. It has been suggested that a state of hypersensitivity might be responsible for this rapid elimination. A subsequent higher serum dosage might presumably also increase the risk of harmful serum reactions. The one important practical conclusion, however, is that once a person has received an injection of any horse serum, he should be promptly immunized against tetanus with the appropriate toxoid (39).

Simultaneous serum-toxoid administration has been the subject of some disagreement since it was shown that the presence of considerable quantities of heterologous antitoxin, following doses of 10,000 units of anti-tetanus serum or more, prevented the usual "sensitization" of the body cells by toxoid and rendered toxoid inert as an antigen (12). Although this may not hold true for the much smaller and possibly less dependable dose of 1,500 units it has generally been agreed upon to allow an interval of from four to six weeks between serum administration and the first immunizing dose of toxoid (11, 59, 12).

Active immunization by toxoid was first introduced on a large scale during World War II. During 1939-40 when approximately 10 per cent of the British troops were still not immunized, seven cases of tetanus occurred in the small non-immunized section, while there were no cases among the 90 per cent immunized. Among the non-immunized German land forces 80 cases of tetanus occurred in the Normandy area alone despite serum prophylaxis, whereas there were no cases in the immunized Luftwaffe (41). No cases of tetanus occurred among the Canadian army personnel who had during World War II received the prescribed course of three monthly injections of fluid toxoid (combined with typhoid vaccine), annual recall injections and booster injections on wounding (24).

Active immunity can be established by three doses 0.5-1 ml. of fluid toxoid or two injections 0.5-1 ml. of the alum precipitated or absorbed toxoids from 3-4 up to 12 weeks apart. A supplementary or first booster dose to follow 6-12 months later has also been suggested. A protective level of immunity is reached within two to three weeks after the third injection of fluid toxoid (second injection of precipitated toxoid) and a greater increase follows the supplementary dose by a further two to three weeks (11). The antitoxin response to basic immunization is better after a longer interval between injections but the inadequate protection obtained after only one injection would be prolonged.

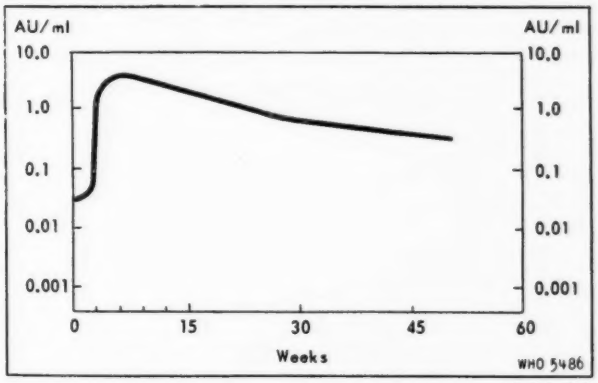


The arrows indicate the times of the second and third injections.

(By Scheibel)

Fig. 1 Schematic Curve of Antitoxin Response to Basic Course of Tetanus Immunization.

Compared with the short duration of passive immunity, *active immunity confers protection which lasts for years.* High levels of antitoxin may be found in the blood 1 to 5 years after active immunization has been established (60) and appreciable levels can be found even after ten or more years (42). Of greater importance is the fact that although the serum titre gradually diminishes over the years the antitoxin producing cells retain an ability to respond with a rapid increase in antitoxin production when stimulated by a recall or booster dose of toxoid. This response results in a significant increase in the amount of circulating antitoxin in from four to six days in the majority of individuals, (3, 8, 9, 29, 48, 65, 67), a period which usually falls within the incubation period of clinical tetanus. With fluid toxoid an increase in titre is usually noted on the fourth day (60); a rapid rise occurs between the fourth and sixth days and a peak is reached by about the tenth to fourteenth day. This response is slightly slower when precipitated toxoid is used and the initial rise may not occur before the sixth post-injection day (48, 60). The response is said to be slower also when the last toxoid injection has been administered more than four years previously (48). Bigler, however, reported a response which was equally rapid with either the fluid or the alum precipitated toxoids (8) and found no decrease after an interval of four years or longer. A booster dose can in any event be depended upon to restore immunity in any previously fully immunized individual up to ten years or more after basic active immunity has been established. A booster, recall or re-inforcement injection of toxoid is usually recommended every four to five years.



(By Scheibel)

Fig. 2 Schematic Curve of Antitoxin Response to Recall Dose of Tetanus Vaccine Given one Year after Basic Course of Immunization.

Toxoids are safe to use and reactions are now extremely minimal (11, 40, 56). Modern methods of preparation have eliminated the use of peptones which infrequently caused reactions including anaphylactic shock. A case of neuritis following the administration of toxoid (69) has been described but was presumed to be due to a reaction to the broth protein of the toxoid. In connection with this case another was quoted by Wooling and Rushton (72) but this case was not fully described and it is not certain whether a similar aetiology was implied.

Perhaps it can be said that no toxoid is absolutely better and more reliable than another provided it is properly prepared and controlled and provided a sufficient number of injections are given. Greenberg and Benoit have, however, produced recent evidence to show that fluid toxoids are not as effective in producing immunity as the absorbed toxoids (32). Some evidence has also been produced (48) to show that the quickest response to booster injections follows fluid toxoid administration in individuals previously immunized with absorbed or precipitated toxoids. Fluid toxoid is therefore still generally recommended for booster injections. In addition, the alum toxoids have two injections compared with the three of the fluid toxoid, they are easily reproduced, and variation in potency from batch to batch is negligible, but they are more expensive. In Canada the potency of toxoids is routinely tested by the Laboratory of Hygiene, Department of National Health & Welfare, and a certain degree of control is exercised in that toxoids of low potency are refused on the Canadian market.

The intramuscular route has long been preferred because of the lesser likelihood of local reactions especially when the combined or alum toxoids are used. Scheibel (60) on the other hand has preferred

the subcutaneous route (scapular or infraclavicular) because of the pronounced local reactions which followed intramuscular injections in Denmark some years ago. Greenberg and Benoit have confirmed the contention that alum toxoids can be given subcutaneously and were so used by these authors with no difference in reactions between fluid and alum preparations. The purification of toxoid and the use of pure alum compounds have decreased the number of "sterile" abscesses to the point where they rarely, if ever, occur (32).

The effect on antibody production of such adverse conditions as poor general health, the presence of diseases of a debilitating nature, the effect of considerable blood loss at the time of injury as might occur in military combat or vehicle accidents has been discussed by Edsall (23). No evidence of such impaired antibody production could be demonstrated.

The "Tetanus Prone" Concept

It has been, and still is, a common practice to assess each injury individually and to administer antitetanus serum to selected non-immunized cases only. This assessment is based on a concept of a "*tetanus prone*" wound which has been variously defined as including every break in the skin surface (52) to "one that has been potentially contaminated with tetanus spores or organisms, particularly in the presence of dead or dying tissue and an atmosphere of low oxygen tension in the depths of the wound which is conducive to the growth of anaerobic organisms" (21).

That this latter type of wound is especially prone to develop tetanus infection no one could deny, but the definition does seem to imply that it would be possible to distinguish between one environment and another as to the possible contaminants present and that there are types of wounds which could be excluded. It is true that the environment may well influence the incidence of clinical tetanus as is shown by the higher incidence in such highly cultivated regions as Normandy in France and among certain more exposed groups such as agricultural workers, horticulturists, stablemen, roadworkers and mechanics.

Tetanus is, however, an ever present hazard and a brief glance at the cases described in the literature amply confirm the universal presence of the organisms (10, 13, 15, 26, 38, 56).

Tetanus has for example been known to follow slight septic abrasions, slight penetrating wounds, as from thorns or a nail in the boot, whitlows, umbilical sepsis in infancy, abortion and childbirth, otitis media, maxillary antritis, infected tooth sockets, burns, carbuncles, septic bunions, cuts which have been stitched or sealed with plaster, varicose and other chronic ulcers, impetigo and other chronic skin infections, frostbite, heroin injections, mosquito or chigger bites. It has also been known to occur from material used in medicine and surgery such as catgut, dressings, cottonwool, plaster of paris, sulphonamide dusting powder, intramuscular injections, and vaccination lymph. It can follow surgical procedures such as dental extractions, operations involving the intestinal tract and excision of scar tissue with the consequent reactivation of spores; and may also be contracted from operating room air.

The character and severity of the wound also appears to have very little significance as far as the overall incidence of tetanus is concerned.

Up to 50 per cent of cases may follow trivial injuries (60) and may even follow non-penetrating injuries (51). Press (56) found that 34.5 per cent of cases were due to trivial injuries and that in an additional 15.2 per cent the nature of the injury was unknown. It is self-evident that a large proportion of these trivial injuries is not of such severity as the type of injury for which medical advice is usually sought in civilian practice.

It is therefore certainly impossible to differentiate accurately those which can be ignored from the prophylactic point of view.

Yet in view of the hazards associated with serum prophylaxis it would be unwise to administer anti-tetanus serum 'blindly'. In the absence of active immunity amongst a substantial proportion of the population, this is a real dilemma. Which wound or type of wound may then be ignored? Gissane and Lowbury (28) have suggested that prophylactic injections against tetanus need not be given in the case of clean superficial wounds or abrasions not more than three to four hours old, and that physical removal of organisms by gentle or thorough washing for three to four minutes may be relied upon. Subsequent contamination must, however, be avoided by a good cover dressing with or without closure by suture or grafting. Conscientiously considered these are about the only types of wounds that may be excluded and then only when they are not contaminated by soil and manure as may occur among farmers, sewage workers, football players, etc.

The additional protection provided by careful surgical wound treatment (with antibiotics in selected cases) cannot be stressed too strongly. There is no doubt that adequate attention to impoverished blood supply, the removal of dead and devitalized tissue, and the avoidance of tension within the tissues by the institution of adequate drainage for the products of injury will afford this additional protection in a certain proportion of cases. Furthermore, immunization should always be undertaken before proceeding with surgical measures on tissues which may harbour quiescent tetanus spores.

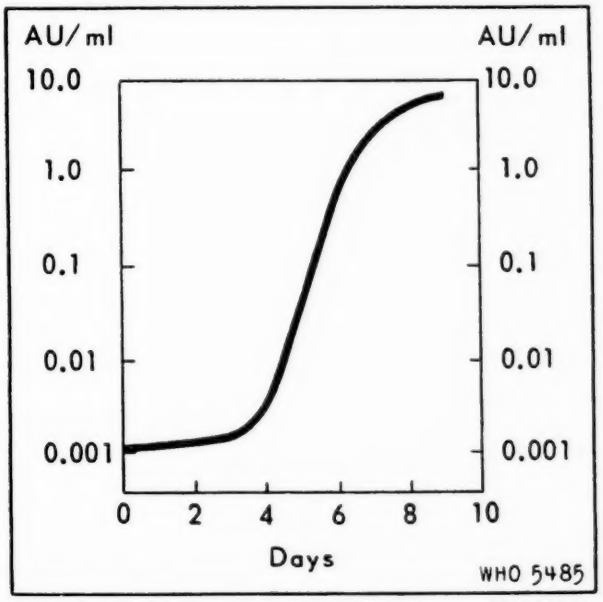
The ideal is obviously active immunization of as large a proportion of the general population as possible. Unfortunately, it has been a failing of past practice, no doubt influenced by the comparatively low incidence of the disease, to relegate active immunization programmes to a minor position in favour of considerations of cost, patient co-operation, etc. Even more unfortunate however, is the fact that physicians are still to a very great extent faced with the problems of potentially serious serum reactions whenever tetanus prophylaxis is contemplated. It has been estimated (56) that at least a seventh and probably a greater proportion of the active population receives one or more doses of serum during life and that nearly a third of the population would, during life receive it if physicians conscientiously administered serum. The implications are obvious as reactions will certainly continue to occur in the presence of sensitivity. Serum administration under these circumstances will remain a problem to the physician.

In this respect it is interesting to note Moynihan's experience (51). Out of a total of 8,900 to whom it was considered necessary to administer anti-tetanus serum, 1,320 (14.8 per cent) did not receive prophylaxis, 1,027 because they had a positive skin reaction, 140 because of a history of previous injections and 70 because of a history of personal or familial allergy; 59 refused.

The Duration of Effective Immunity–Booster Doses

There has as yet been no final agreement on several aspects related to the *duration of effective immunity* so provided and hence the frequency with which booster doses might be required.

Clinical cases, unfortunately, do occasionally occur despite active immunization (9, 41, 48, 60). Analyzing the possible causes of this incidence, consideration must be given to an over-production of toxin such as is found in overwhelming infections. The level of immunity at the time of injury may be too low to protect against tetanus either because of a defective antibody response to basic immunization (present among a small percentage of individuals) or a gradually diminishing circulating antibody titre. There is also a potentially dangerous period of from one to six days in between a booster dose and the booster response, a period which may be greater than the incubation period in fulminating cases.



(By Scheibel)

Fig. 3 Schematic Curve of Antitoxin Response to Recall injection of Tetanus Vaccine in Previously Immunized Persons.

The level of immunity considered sufficient to protect against tetanus is a very arbitrary one. Based on past experience and by analogy to the effectiveness of and the level of immunity produced by a dose of 1,500 units of anti-tetanus serum, this has been estimated at between 0.01 and 0.1 (8, 12, 41, 49) units of circulating antitoxin per cc. of serum. With this as a basis Moss (49) et al found that 97 adequately immunized individuals out of a total of 100 reviewed, had circulating antitoxin titres of more than 0.01 units six to ten years after their last inoculation. The three individuals in their series with lesser amounts could not be regarded as having received adequate basic immunity, in addition to which they had received their last inoculation 11, 13 and 15 years before respectively. All 100 individuals, however, responded to a booster injection to a level more than sufficient to protect them against tetanus.

To the industrial physician this series could be of great significance because it would appear to indicate that emergency booster doses at the time of injury might be dispensed with provided adequate immunization has been established and provided this immunity has been maintained by regular booster doses. It is of importance to the industrial physician because many injuries, including a larger proportion of trivial injuries than normally seen by civilian physicians, are attended to in industrial health centres daily. Administration of an emergency booster dose of toxoid to all cases of injury in civilian practice as has been the practice in the armed forces would, depending on the accident rate, be another heavy undertaking.

The duration of effective toxoid immunity has been the subject of several other investigations. Looney et al for example (42) found that only one of 144 individuals had a titre of less than 0.025 units three years after the last immunizing injection of toxoid. Stafford et al (65) reported that six of 72 individuals who had last received toxoid five to eleven years previously had titres below 0.01 units whilst 75 per cent had titres over 0.05 units. In another series of 73 men who had last received toxoid less than five years previously he found three men with titres less than 0.01 units whilst 93 per cent had titres over 0.05 units. According to Long & Sartwell (41), of 42 individuals who had not received toxoid during the previous two to five years all had remaining levels of at least 0.01 units. In another investigation, Peterson et al (53) reported on the immunity of 200 veterans who had received their last toxoid injection one to eleven years previously. None of these men had titres of less than 0.1 units of antitoxin unless more than three years had elapsed.

According to Looney et al (42), there is growing evidence to the belief that the extreme rarity of tetanus in the American Armed forces during World War II may have been due more to the establishment of an adequate antitoxin serum level than to the use of the emergency booster. Furthermore there has been a greater drop in the incidence of tetanus among American males 20-39 years of age since the war than in any other age group except young children. This lowered incidence was unquestionably due to the wartime immunization of military personnel in this age group indicating also that the effectiveness of the immunity so obtained may have protected them for at least a number of years since their last injection of toxoid.

A number of authors are in agreement that it is preferable to maintain an adequate level of immunity at all times by an accepted series of boosters rather than to place sole reliance on the efficacy of the booster dose at the time of injury. Further, successive periodic

boosters tend to raise the antitoxin level higher and this ensures increased and generally prolonged protection.

In view of the outline above, it would therefore seem reasonable to suppose that immunity against tetanus might be effectively maintained with routine booster inoculations given every 3 to 5 years after active immunity has been established, and that emergency boosters at the time of injury could be omitted at least for the first 2 to 3 years following the last immunizing dose of toxoid in individuals so immunized. Recent evidence that successive boosters might temporarily produce a negative immunity state, co-inciding with the period during which immunity may be most needed, supports this contention (4).

It is said that the occurrence of *infection with Cl. tetani* serves as sufficient stimulus to antitoxin production in immunized individuals although this may not occur until approximately the tenth day. It is therefore interesting to note that the cases of tetanus among the immunized armed forces personnel usually followed extreme trauma or heavy contamination and with the incubation period often being less than a week. Under these circumstances it is possible that the emergency booster did not exert its effect fast enough, implying also that the incubation period fell within the period before a booster response usually occurs. This would indicate not so much the need for an emergency booster but rather a supplementary dose of tetanus antiserum in a limited number of cases. There appears to be no contraindication to the simultaneous administration of serum and toxoid when this is required to those already immunized provided these are administered with two separate syringes at different sites (extremities) (21, 48, 60).

In all cases of injury most likely to lead to the fulminating type of tetanus infection, an injection of anti-tetanus serum as well as an emergency booster may therefore be considered advisable. This would apply particularly in cases of injury around the head and neck, multiple injuries, injuries extensively contaminated or when there has been a delay of more than 24 hours before the institution of surgical treatment.

Medico-Legal Aspects

As the first line of medical or surgical defence against the possible consequences of injury including wound infection, it would be the aim of the industrial physician to assess in addition the patients resistance to tetanus infection, and if necessary, to raise it to a reasonably effective level. Because of the critical incubation period in some cases and the delay and confusion which may follow referral of the patient to hospital or to this personal physician, it is preferred that the industrial physician should take this responsibility upon himself. Apart from the disease consequences, failure to adequately consider the immunization status of the individual may, in cases developing clinical tetanus, be followed by threatened and actual legal action. This has unfortunately occurred in the past (25, 51) and may continue to occur if tetanus prophylaxis is to be carried out in a haphazard way.

Like all *medico-legal questions*, failure to provide protection against tetanus is naturally a very complex problem. In a recent article Fisher (25) summarized this problem as follows: "If a doctor fails to give anti-tetanus serum under circumstances that would have prompted ordinarily competent doctors to give it, he probably will be held legally responsible for any ill results that can be shown to have followed because of its 'omission' " and further: "failure to administer anti-tetanus serum when it is indicated can be excused only if it be known that its administration would expose the patient to greater risk than withholding it."

As far as the actively immunized are concerned there appears to be sufficient reason for the belief that the decision to omit an emergency booster at the time of injury within a reasonable period since the last immunizing or booster injection of toxoid should be regarded, even though arbitrary, as reasonably competent and safe medical care.

A further medico-legal aspect of tetanus prophylaxis is the potentially disabling serum reactions. The practice of putting an employee's refusal to accept active immunization procedure in writing in the same way in which it might be required from the non-immune when serum administration is being considered is understandable.

An Active Immunization Program in Industry

One important factor to be considered when initiating any *new programme* is the question of *cost* to the industry. In Canada, however, toxoid is supplied free of charge on application to provincial health authorities. This would in most cases apply to the provision of fluid toxoid and cost may therefore become of significance only when the alum precipitated, absorbed or combined vaccines are being considered for use.

But there are other factors which may directly or indirectly affect the economy of the industry. These will include lost manhours as a result of serum reactions necessitating either absence from work or a period of light duty, and the cost of drugs necessary to suppress serum reactions. More difficult to assess would be the actual effects on production, in terms of dollars and cents, as a result of serum prophylaxis.

Yet even with the approval of management, full employee co-operation may present a problem. A complete explanation of the advantages of such a programme to all the employees should go a long way to ensure its success. As Lutz (43) has suggested employees should be told that active immunization is

similar to the type of treatment given every soldier; that in the case of civilian disaster it would be an extremely valuable protective agent; that in case of injury it would protect the patient against one of the most serious types of infections known; that constitutional symptoms very rarely occur, and when they do, they are never severe; and that immunization is given without cost to themselves.

It is obviously impossible to make any scheme compulsory but its importance can be stressed by making it known as the official attitude of the management to the problem. Those who refuse despite these considerations may be requested to sign a release as an additional legal safeguard to the medical service involved.

The whole industrial population can be covered at a rate which only the industrial physician can decide. Programmes must therefore be tailored to existing circumstances. The most convenient starting point of any new programme is with the new employee. These may then be followed by old employees returning from sick leave and in turn after a number of months perhaps, by old employees periodically examined, etc. This scheme has much to commend itself as a means of controlling the additional load on the medical service such a programme would entail. (See Appendix I)

The injections together with a full immunization history with special reference to military service and school-going booster injections are naturally to be fully recorded and kept by the physician. A record card completed by the physician at each visit and carried by the employee at all times, has very obvious advantages. It may also be used to record other inoculations as well as vital information such as blood groups, diabetic status, etc.

SUMMARY

Active toxoid immunity with its universal effectiveness, its much higher degree and longer protection, is an obvious ideal in view of the high case mortality, the universal presence of spores, the frequency with which passive immunization would be required if the number of actively immune is limited, the consequent dangers associated with serum reactions, the insignificance of injuries capable of resulting in tetanus, the not infrequent failure of anti-tetanus serum prophylaxis and the reduced effectiveness of serum prophylaxis after previous serum administration.

The introduction of active immunization programmes as an integral part of industrial medical care would, in addition, safeguard individuals who because of the nature of their employment are exposed to a greater risk of tetanus; it would reduce the chance of discomfort and illness as a result of severe reaction to the patient, and would consequently reduce the cost of lost time to the industry. It would increase the number of immunized significantly in the event of any future war. It would eliminate to a very large extent the inconvenience of the sensitivity testing and desensitization procedures.

In conclusion it cannot be too strongly stressed that tetanus is an almost completely preventable disease, and as such active immunization procedure is a hundred per cent worthwhile in industry.

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APPENDIX I

It is often desirable to have written instructions available. The following procedure is being suggested for further adaptation to the needs and requirements of individual medical units (adapted from Parish et al) (53).

A. *New Employees.*

I. *Non-immune:* This category includes individuals who may have an inefficient immunity; (a) Those who have never received any injection of tetanus toxoid; (b) those who have received only one injection of tetanus toxoid; (c) when more than 1 year has elapsed after two injections of fluid toxoid or when more than ten years have elapsed after the initial course of tetanus injections or a subsequent boosting dose; (d) when there is any doubt about previous toxoid administration.

Recommend active immunization by toxoid. If he she is willing, proceed as recommended for the toxoid to be administered, e.g., for fluid toxoid administer three ml. injections at approximately six-weekly intervals and follow up with a supplementary injection 6 to 12 months later. A periodic booster dose to follow every 4-5 years.

II. *Immune:* (a) for a period up to 1 year when only two injections of fluid tetanus toxoid have been received, when the second injection was given not less than six weeks and not more than twelve weeks after the first injection; (b) for a period up to 10 years when three or four injections of tetanus toxoid, depending on the toxoid used, have been received, the last injection being given not less than six months and not more than twelve months after the second or third injection above; (c) for a period up to 10 years after a boosting dose has been received following a full primary course of immunization.

Recommend a boosting dose of toxoid when more than four to five years have elapsed since the last immunizing dose of toxoid.

B. *At Time of Injury.*

I. *Non-immune:* (as above)

An injection of anti-tetanus serum is required unless the wound is superficial, less than 3-4 hours old and capable of being thoroughly cleaned.

Give anti-tetanus serum in accordance with the following procedure (53).

(1) Try to obtain the patients previous history of: (a) injections of horse serum of any kind, and (b) allergic conditions, especially asthma and infantile eczema.

(2) If no previous serum and no history of allergy, give full dose of anti-tetanus serum, 1,500 international units, subcutaneously or intramuscularly. If there are any doubts about previous injections of serum or allergic diathesis, proceed as in (3).

(3) If the patient has had serum before, but has no history of allergy, give a "trial dose" of 0.2 ml. of undiluted anti-serum subcutaneously. If no general symptoms develop within 30 minutes, give a full dose of anti-tetanus serum, 1,500 international units, subcutaneously or intramuscularly.

(4) If history of allergy, give a trial dose of 0.2 ml. of 1:10 dilution of anti-serum subcutaneously. If no general reaction within 30 minutes, give 0.2 ml. of undiluted anti-serum subcutaneously. If no general reaction within a further 30 minutes, give full dose of anti-tetanus serum, 1,500 international units, subcutaneously or intramuscularly. The object of the trial dose is to determine any predisposition to general reaction and not to detect any local reaction, the latter having no practical significance. (If symptoms develop these must be treated immediately).

(5) Additional prophylactic doses (usually 1,500 international units) subcutaneously or intramuscularly, may be given at weekly intervals if the surgeon in charge of the case considers this necessary.

(6) Whenever anti-serum has been given active immunization should be recommended and should commence six weeks later.

N.B. Keep a small sterile syringe and a 1:1,000 solution of adrenaline ready for emergency use whenever anti-serum is administered. Antihistamine drugs, ACTH, cortisone, adrenaline, and ephedrine can be used to offset or suppress serum reactions in sensitive patients. Oxygen, aminophylline, solutions of dextrose for intravenous use, l-arterenol or other similar drugs and a tracheotomy tray are other articles that should always be available. Keep the patient warm and under observation for at least 30 minutes and tell the patient to report any untoward reactions promptly.

IMMUNIZATION RECORD

Surname: Given names: Date of birth:

Address: Telephone:

Previous Immunization History (type of vaccine, reactions, allergies)

Blood Group: Rh.

TETANUS TOXOID

DATE	TYPE OF TOXOID	AMOUNT	BATCH NO.	COMMENTS	GIVEN BY

(NOTE — Back of card to be used to list other vaccines.)

II. *Immune:* (as above)

(1) If less than two years since last immunizing dose of toxoid, (full course or booster) not even an emergency booster may be required.

(*Concluded on page 21*)

THE ROLE OF THE INDUSTRIAL NURSE IN REHABILITATION*

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The responsibilities of the industrial nurse have always included some aspects of rehabilitation of employees. At first the nurse was employed by industries to provide home care but gradually the emphasis has changed and in the main, the majority of nurses now render their services within the industrial health centre. As programs are set in motion for full-scale rehabilitation of handicapped persons in the health schemes of many countries the role of the industrial nurse should be scrutinized and brought into the orbit of the total rehabilitation program. On the basis of experience alone the industrial nurse has much to offer, and rehabilitation programs will not be complete until her services are included. In this, each industrial nurse has a responsibility which is to interpret her role, and seek a place on the rehabilitation team.

Rehabilitation has been defined as "the restoration of the handicapped to the fullest mental, social, vocational and economic usefulness of which he is capable." With this definition as a guide, the industrial nurse will need to know the broad rehabilitation program which has been planned in her country, to be fully aware of the basic philosophy, the objectives, scope and limitations which influence the service.

A Canadian physician has pointed out that "the services required to assist with rehabilitation will include medical, psycho-social and vocational. It should be emphasized first, that rehabilitation is a continuous process and second, that medical interest extends right across the field. Rehabilitation is not a third phase of medicine. It is part of good modern medical care. Health departments at various levels should accept the responsibility for integrating and coordinating this developing program into the medical care arrangements for the area. They should also ensure that these arrangements blend with the psycho-social and vocational aspects."

*Presented at: The International Congress on Occupational Health Helsinki, Finland, July, 1957, by Miss Heidi Hendrickson, Consultant in Occupational Health, Minnesota State Department of Health, Minneapolis, Minn., U.S.A.

Basic to a great movement such as rehabilitation are certain concepts upon which the service is planned. Some of these include:

1. Rehabilitation personnel respect the integrity and personal worth of every individual. This is sometimes referred to as the personnel point of view and is basic to good industrial medical programs.

2. In primitive societies, handicapped members are usually left behind as the tribe moves on. In more advanced societies the handicapped are carried along, frequently with great difficulty. Rehabilitation programs are designed to help these people to help themselves, so that they may develop a feeling of personal self-worth and at the same time assume a worthy place in society.

3. The horizons of health and welfare planning are being broadened to include all handicapped persons. At the same time it is being recognized that the healthy person may become disabled for a time, but with assistance may regain full capacities with as little psychological and physical trauma as possible.

4. It is accepted today that rehabilitation is the responsibility of the total community. Previously, the patient in hospital tended to become a medical entity rather than a person. His treatment was inclined to follow an assembly line pattern and was limited to the physical disability itself. Many hospital problems of social origin today stem from this point of view. Some of the disgruntled attitudes of people towards hospital care are based upon unresolved social problems not recognized during their illness. The increased demand for hospitalization will necessitate increased facilities for rehabilitation of the patient who has no suitable home care and must remain in hospital beyond the time when he no longer requires such services.

5. The changes in our way of life brought about by increased industrialization, extended travel and communication privileges, and the possibility of disaster, natural or provoked, necessitate increased facilities for rehabilitation.

6. Improvements in medical and surgical care, which have resulted in a greater expectancy of survival, have been extended to give earlier and more efficient care to the injured, the diseased, and the disabled individuals in society.

The development of today's rehabilitation programs began with the pioneers of industrial medicine through the introduction of emergency care for occupational and non-occupational accidents and illnesses. Evolving from this industrial social development came Workmen's Compensation legislation whereby the risks of occupational hazards no longer were carried by the employee alone but were shared by the employer and society. At about this time, a number of countries introduced good medical programs for disabled veterans of World War I. Following World War II, the rehabilitation program became even more highly socialized. Manpower demands during the war revealed the large number of handicapped people in society and also brought recognition of the contribution which these individuals could make if given medical supervision and adequate vocational guidance.

The industrial nurse has participated in the veterans' rehabilitation program by giving health guidance to the veteran and by interpreting veterans' rehabilitation services to management when such services were required. The nurse in industry has frequently wished that such competent medical services were available to all the handicapped employees. She will welcome the larger, more comprehensive rehabilitation services which have been set up mainly within the last decade through legislation and government assistance. In summary, the industrial nurse's future program of rehabilitation will be twofold — (1) continuation of assistance in industrial rehabilitation to the employees she serves, (2) assistance in rehabilitation services to the handicapped citizen who will be employed by her management as a part of the more comprehensive community program.

The rehabilitation concept is so closely interwoven into all phases of the nurse's responsibilities in occupational health that it is truly difficult to separate it for observation. For this reason the full scope of occupational health services is defined and it illustrates the many ways rehabilitation enters into the program.

In this discussion it is assumed that the nurse is practising her professional role with medical guidance. The future programs of rehabilitation, to be complete, will have medical guidance for all occupational health nursing services. Without medical guidance, the role of the industrial nurse is extremely limited and creates too many hurdles to be considered here.

The scope is outlined as follows:

1. Emergency care for occupational and non-occupational accidents and illnesses.
2. Physical examinations.
3. Health education; counselling to assist in vocational adjustment; and rehabilitation.
4. Participation in plant safety, sanitation, and welfare activities.
5. Co-ordination with community health and welfare agencies.
6. Supervision of illness absence, which may include home visiting and arrangements for home care.
7. Communications through records, reports, participation in the company's public relations as supplied to the health services; conferences for interpretation of the health services to all concerned, beginning with the individual employee to supervisors, line management and top management, and to the community agencies concerned.

Emergency care for occupational and non-occupational accidents and illnesses is the oldest part of the program in occupational health. Its value was recognized early by owners of industries, who established medical and nursing services for their employees. Employees need to feel that their place of work is relatively safe, and that industrial management takes every precaution to provide safety measures for its workers in hazardous situations.

In minor accidents the nurse gives aseptic care to any break in the skin. In so doing, she solicits the co-operation of the employees to come early to the Health Centre for service so as to reduce the possibility of infection, which could lead to lost time, disability, and the need for rehabilitation back to the job. With this service she gives instructions to the employee for off-the-job care of the injury. Thus health education is carried over to the home, where it may be applied to home accidents and illnesses.

Every industrial medical service has known pride of achievement in the knowledge that in some instances

employees might have been severely handicapped except for foresight and planning. An example may be cited of the young man who accidently dropped a container of sulphuric acid, causing the acid to splash in his face and eyes. This occurred two days after printed instructions for chemical burns to the eyes had been placed in his work area. When he came to the Health Centre, he said immediately "I did exactly as your instructions told me to do, and I can see!" With a completed cycle of treatment, he retained his normal vision. If such a situation had not had a successful outcome, rehabilitation services would have been continuous during the lifetime of the employee.

The physical examination program of the Health Service will vary according to the policies of the company. These examinations are performed by the physician, assisted by the members of the nursing staff. The program usually includes pre-employment health appraisals for all new employees. Those who are handicapped need special consideration to implement the rehabilitation program in the community, and to assist the individual to match his capacities to his new employment. The community rehabilitation personnel will need to help plan supervision for handicapped citizens in industries without medical programs.

As the prospective employee receives his medical examination, he is informed of the functions of the health service and he is invited to return at any time for assistance. It is important to inform the industrially disabled or the handicapped person and his supervisor that the personnel in the medical department are interested in the disablement and are "standing by" to interpret the health needs and to give support when necessary. It should not be taken for granted that the supervisor or the disabled person understand the full medical significance of the case in question.

Other types of examinations are referred to as periodic and special medicals. The purpose and scope of these, also, depend upon company policies. The periodic examination may be scheduled at stated intervals as a health appraisal of the handicapped or disabled employee. At this time there will be a discussion of limitations and a check up of prosthetic devices. The special examination is performed in cases of suspected exposure to toxic materials, for transfer to another department, or to lighter work to meet the needs of the aging process. The return-to-work medical appraisal is a very important tool in rehabilitation. In this situation the employee is returning to work after an accident or illness with recommendations from his family physician. At this time an opportunity is provided for guidance in health and job adjustment, and is a means for cooperation with the community resources.

Woven through all these physical examinations are the concepts of rehabilitation mentioned above, which must be coordinated smoothly with the job placement and supervision pattern of the industry. The main objective is to assist the employee to develop an assurance of adequacy and a feeling of security in his job. This, in turn, influences his home and his family and, indirectly, his community, towards good mental health.

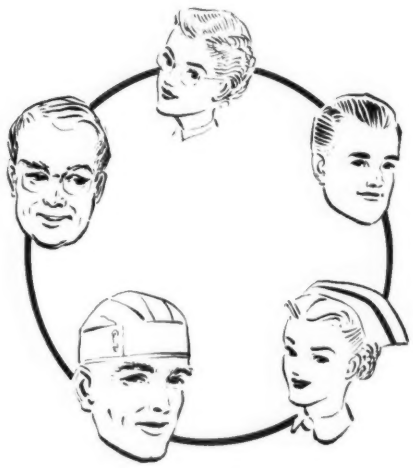
Today, handicapped persons are employed in many industries, especially where members of management have had satisfactory experience with disabled veterans. Thus management assumes its social responsibility to the community. With medical supervision many remedial defects in these handicapped employees will be identified and corrected, thus increasing the employee's productive capacity. Examples are dental care, eye corrections, orthopaedic problems, skin care and general nutrition. Defects found in the pre-employment examination by the physician may be subject to correction as a requirement of employment. When the larger rehabilitation program is available to all handicapped citizens, medical guidance will be more accessible for the worker disabled through circumstances other than occupational. To make the rehabilitation program truly successful, there will need to be more personnel for health supervision and guidance in industries.

Health education, health supervision and counselling are essential services in occupational health and will be of considerable assistance to promote the larger rehabilitation program. The nurse who has preparation in health education and has known success in planning such a program usually has an effective health education program for all employees in the industry. Some nurses plan their program only for those employees who come to the Health Centre seeking medical or nursing service. This is only a small percentage of the total employee group. When rehabilitation services become general,

a more active correlation of all health and welfare programs will follow. This will act as a stimulus to both occupational health and the traditional public health through team work.

Safety at work receives attention from all members of industrial management, as it is a very important factor in the prevention of accidents. The physician and nurse play an important supporting role in the safety program of the company. When an accident does occur, early and efficient medical care greatly reduce the degree of disablement and the amount of rehabilitation which follows. As rehabilitation includes treatment of emotional trauma associated with the injury, the medical management of the accident or disaster situation influences the success or degree of recovery. Therefore, medical rehabilitation includes reduction of the psychological trauma as well as the repair of physical damage. The promotion of safety, the prevention of accidents, and the care of the injured when an accident does occur, are shared by management and the medical personnel.

The counselling responsibilities which have been added to other services in occupational health are valuable in assisting the disabled employee to make a satisfactory adjustment to his work. Maintaining rapport with all workers in the course of normal duties presents the nurse in industry with a counselling situation. Problems of interpersonal relationships are brought to her daily by employees visiting the Health Centre for various other reasons. When such requests involve handicapped or disabled employees consultative assistance will be supplied to the industrial medical personnel by well qualified counsellors at the Community Rehabilitation Centre.



Team work is an essential factor in the planning of rehabilitation programs, and employment conditions must be understood by all members of the team. Coordination with community health and welfare resources will strengthen the links of rehabilitation with industrial management through its medical personnel.

Today some occupational health nursing services include home visiting to the injured employee in his home or in the hospital. This provides a unique opportunity for interpretation of the rehabilitation process; many problems can be solved through a better understanding of the employee's needs related to his home and work. However, well defined objectives and policies are essential for a successful home visiting program by occupational health nurses.

In conclusion, the industrial nurse may contribute to the effectiveness of a rehabilitation program by:

1) Informing the rehabilitation specialists of her role in the industrial medical services so that it may be integrated with the rehabilitation program of the community.
2) Spending some time at the rehabilitation centres set up by Workmen's Compensation Boards to become acquainted with the objectives, scope and management of their programs. Every rehabilitation centre has the same objective — to rehabilitate the injured worker physically, emotionally, vocationally, and socially.
3) Developing better communications to understand the role of each specialist as it relates to the group effort in rehabilitation.
4) Obtaining formal preparation for industrial nursing to increase her ability to make full use of community health resources. This will include as well, experience in health education and a satisfactory adaptation to the field of commerce and industry.

Rehabilitation as related to occupational health can offer service to handicapped persons in all occupations. This may be in the home, on the farm, in an office or in a manufacturing industry. Successful rehabilitation programs will have a marked effect on the health and happiness of the individual, the family and the community. When we read the literature, hear the planning and see rehabilitation in action, it is realized that there is a truly great future for service in industrial nursing and a broader scope for occupational health services.

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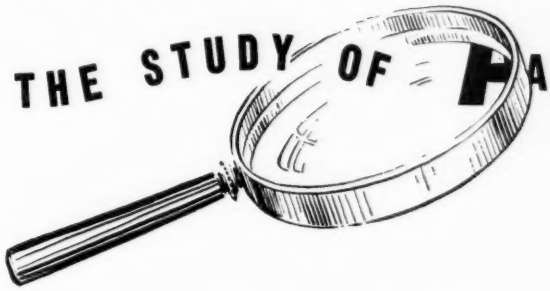
SOME ANALYTIC AND CLINICAL METHODS IN THE STUDY OF ATMOSPHERIC POLLUTION*



by P. J. Lawther, M.B., M.R.C.P.
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The presentation of this paper at a conference on the use of instruments in occupational hygiene can be justified only by the acceptance of wide definitions of terms. The Shorter Oxford English Dictionary defines an instrument as "a thing with or through which something is done or effected; a means; a person made use of by another person or being for the accomplishment of a purpose," and occupation as "the taking up of space and time; the being occupied with or engaged in something." This essay can be submitted in the light of these definitions.

The object of the use of instruments in air pollution research must next be considered. We are ultimately concerned with the investigation of the clinical consequences of contaminated air and this great problem may be broken down into several parts, each requiring the application of different techniques. This clinical aspect of air pollution is reviewed more fully elsewhere (Lawther, 1956). Low-grade chronic urban pollution is suspect as a possible aetiological factor in the production of chronic bronchitis and lung cancer, and the severe acute pollution experienced during temperature inversions is known to have a harmful effect on patients whose respiratory function is impaired by pulmonary or cardiac disease. Obviously the proper investigation of the clinical effect of dirty air necessitates detailed knowledge of the chemical and physical nature of urban pollution which varies greatly both in quantity and quality. The character of polluted air must be studied concurrently with the health of susceptible patients in order to seek some association between specific pollutants and clinical deterioration. While these analytical and epidemiological aspects of the problem are being studied, suspect pollutants are being tested for possible physiological effects; volunteer patients and normal subjects are exposed to gases and aerosols in a chamber and any effects, particularly on pulmonary function, are measured. The importance of the analytical and epidemiological methods may be emphasised by consideration of some of the limitations of the experimental exposure technique; experiments must be confined, especially when the subjects are patients, to attempts to produce only effects which are rapidly reversible, such as bronchospasm; exposures are necessarily of relatively short duration and are properly limited to the application of selected isolated factors. The results of such experiments cannot safely be used to predict the behaviour of man when exposed to complex urban pollution over long periods; they will tend to produce negative results which will exonerate rather than incriminate individual contaminants. Linear relationship between cause and effect is rarely seen in biology and extrapolation is fraught with academic peril. The time taken for a guinea pig to die when exposed to 500 p.p.m. sulphur dioxide is of strictly limited relevance to the plight of an old man with emphysema who is laid low with bronchospasm on a smoky day when the concentration of sulphur dioxide reaches only 1 p.p.m. The study of the patient in this polluted environment is to be preferred to the direct experimental approach though the latter method is obviously of great complementary value.

Our use of instruments is directed, therefore, mainly to the determination of the nature of the patient's environment and to the assessment of his clinical status. This task requires the use of a host of instruments from stethoscopes to spectroscopes and in a paper of this size only a few can be selected to the exclusion of many. For a clinician to embark on a catalogue of complex physical instruments would be impertinent and for comprehensive reviews of the subject reference should be made to the excellent papers given to the Instrumentation Panel of the U.S. Technical Conference on Air Pollution (Proceedings edited McCabe 1952) and to the recently published Air Pollution Handbook (Magill, Holden, and Ackley, 1956).

*Presented at the Conference of the British Occupational Hygiene Society, "The Use of Instruments in Occupational Hygiene".

†Reprinted from "Instrument Practice", June 1957.

The degree of air pollution throughout the country is approximately indicated by the measurements of smoke and SO_2 made under the auspices of the Fuel Research Station of the D.S.I.R. (The Investigation of Atmospheric Pollution, 1955). Monthly averages of sulphur dioxide concentrations are determined by the lead peroxide method which depends on the fact that SO_2 reacts with lead peroxide to give sulphate which is readily determinable. This method was originally developed to give estimates of the effect of polluted atmospheres on buildings but the results have been used to derive approximate figures for SO_2 levels in the 1952 smog (Wilkins, 1954). There are 1,042 peroxide instruments in Great Britain.

Of much greater value are the daily "volumetric" smoke and SO_2 instruments of which there are 130 in operation at present. (There are, in addition, 44 instruments which measure smoke alone.) By means of a small electrically operated pump air is drawn at a rate of about 50 cu. ft. per day through a Whatman No. 1 filter paper, a Dreschel bottle containing hydrogen peroxide, and a domestic-type gas meter. The air enters through an inverted funnel and is led to the filter through hard glass tube of internal diameter 3/16 in. It is claimed that the linear velocity of entering air is about 0.1 ft./sec. from which it is calculated that particles up to about 20u diameter are being sampled. The smoke produces on the filter paper a black stain the density of which (measured either by photoelectric reflectometer or by comparison with a scale of shades) is translated into terms of milligrams per cubic metre. The sulphur dioxide is oxidised in the bubbler and the resultant sulphuric acid is determined by titration. This method of assessing air pollution has many limitations some of which are discussed by Parker and Richards (1952) but the data it produces are the most valuable at present available over wide areas.

There is a danger in accepting the results of 24 hour mean values as indicating a true hazard to health; peak concentrations may be of much greater toxicological significance and the enormous variations which can occur over short periods are shown in Fig. 1 (Waller and Lawther, 1955.)

Obviously such observations cannot be made routinely and continuous automatic recording instruments are of value on such occasions; but it will be noted that their range needs to be great in order to cope accurately with such large variations. The automatic SO_2 recorder recently described by Cummings and Redfearn (1957) seems to meet these requirements.

It must be emphasized here that the measurement of smoke and SO_2 does not imply that these pollutants are necessarily specially injurious to man; they may indeed be harmful but at present it is wiser to regard them as indicators of particulate and gaseous pollution.

Any belief that the ill effects of air pollution may be simply ascribed to smoke and SO_2 is dispelled by contemplation of the wonderful complexity of particulate contaminants revealed by the electron microscope. This instrument is surely the most powerful which has yet been brought to bear on the analytical problem and the pioneer work of the Safety in Mines Research Establishment is producing exquisiste techniques by means of which the nature of minute particles may be studied (Cartwright, Nagelschmidt and Skidmore, 1956, and Nagelschmidt, 1957). Samples are collected with the thermal precipitator in which a known volume of air is drawn slowly through a narrow gap past a heated central wire. On each side of the gap are mounted two microscope cover slips on which the thermal gradient deposits the particles from the air as it passes through. The cover slips are coated with films of Formvar about 200°. A thick and these, on which the particles have been deposited, are stripped off and mounted on specimen grids for examination in the microscope. Cartwright et al. (1956) have developed a new technique using heat-stable membranes of aluminium oxide which permit the observation of the effect of heating the particles to known temperatures. Much is thereby being learnt of the composition of urban smoke.

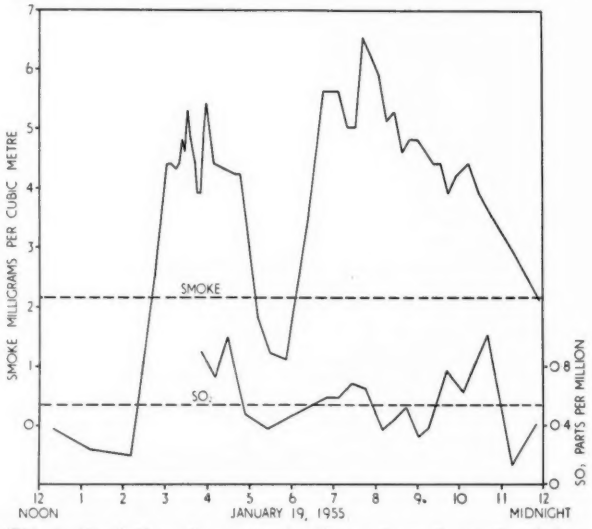

Fig. 1 Variations in concentrations of smoke and sulphur dioxide on the roof of St. Bartholomew's Hospital. E.C.I. on Jan. 19/55 (Daily mean figures shown by dotted lines).

The fate of these particles on inhalation and the effects they have on the lung are of prime interest. Most of the existing knowledge of the penetration and retention of particles in the lung has come from work on dusts and aerosols in connection with the pneumoconioses. These experiments and calculations have been mainly concerned with idealised spherical particles. It may be truly said that the electron microscope has opened up a new world from which it can be seen

how sadly inadequate were previous concepts of particulate pollution in crude terms of smoke and grit.

At the present time, when physical instrumental techniques are developing with bewildering rapidity, it is easy to forget that the object of our studies is biological, and that a direct approach to the problem is preferable to one involving intermediate measurements; the object of our tests must be used, when possible, as indicator and assessor. Thus, in California air pollution can cause severe damage to spinach crops, and so the spinach plant is properly used as an instrument for the estimation and study of specific pollutants. Sulphur dioxide produces damage in different plant species which is histologically distinct from that caused by Los Angeles "smog" and by fluorides; plants may thus be used as delicate and specific instruments in research work which has their salvation as its primary object. (Thomas and Hendricks, 1956.) Likewise, Los Angeles "smog" is a great nuisance because it causes lachrymation; despite an enormous amount of analytical work the compounds responsible for the effect have not yet been identified with certainty and it is refreshing to see that, amidst complex analytical machinery, the human subject, the proper object of the work, is used as an instrument to assess lachrymatory properties of suspect compounds. The principle is again well illustrated by consideration of the problem of pollution in streets by carbon monoxide from petrol vehicles. One may sample the air instantaneously at a time of peak pollution and analyse it; or one can take a large sample slowly over 12 or 24 hour periods and then determine an average concentration; with an automatic recording infra-red analyser a record can be obtained of the precise manner in which the concentrations fluctuate. Air samples may be taken in evacuated bottles or collected by bubbling the air through blood. Any of these results must then be translated by reference to graphs and tables derived from the research work of others to provide ultimately an estimate of a possible hazard to men of such a size engaged in a specific activity for a specific time. It is sometimes forgotten that man himself is the best CO sampler and that by determining the CO content of his blood after he has performed a stated task in the environment in question much speculation and difficulty may be avoided. That is the method we are using in our study of pollution in London streets. Man is better than an evacuated bottle. Haldane was applying the same principle when he took canaries down mines; the bird is a most valuable instrument supplying vital information and if it is subject to error, the error is always on the safe side.

Nearly three years ago we started a crude biological experiment using patients with chronic bronchitis as our instruments in an attempt to determine the circumstances responsible for their clinical deterioration. We were fortunate in having a well controlled group of patients at St. Bartholomew's Hospital whose clinical condition had been carefully followed for several years (Bates, Knott and Christie, 1956). They were the first to take part in the investigation. Later (in the winter of 1955-56) about 150 patients from four other clinics in London and from clinics in Manchester, Sheffield and Birmingham, joined in the experiment. Commonly, patients with chronic bronchitis maintain that certain types of weather or different kinds of fog make them worse and they vary in their dislikes. A visit to a clinic at intervals of a month or so does not permit this valuable information to be elicited with any great degree of accuracy since remembrance of individual days is often vague. Therefore it was decided to ask the patients to write in a diary their own assessment of their condition according to the following simple code and instructions which were pasted inside the diary:—

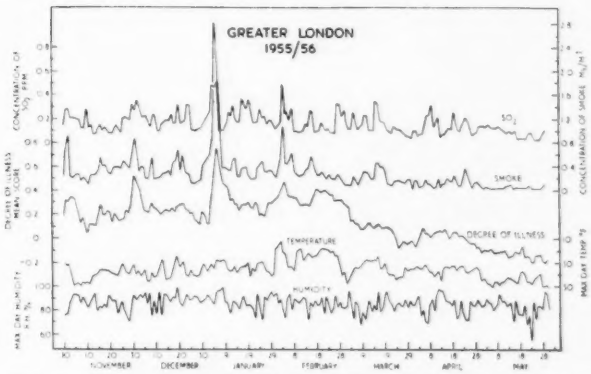

Fig. 2 Graph showing "degree of illness" of 180 patients in Greater London with chronic bronchitis plotted with smoke and SO_2 concentrations, temperature, and humidity (Diary experiments).

Bronchitis Investigation Instructions

Please write a letter in the space for each day as follows:—

A. If your condition is better than usual
B. If your condition is the same as usual
C. If your condition is worse than usual
D. If your condition is very much worse than usual.

It Is Important to Write one of these Letters in the Diary Every Day

If you are ill or have to go into hospital please ask your closest relative to fill it in for you until you are well again.

In addition to the above write:—

F. If there is a fog some time in the day
X. If you have head or chest cold that day
H. If you stay indoors all day.

If you want to make any special note, please do.

The simplicity of the instructions will be noted; it was felt that any attempts to elicit more specific informa-

tion (such as various symptoms of chest trouble) would render the results invalid by overburdening the patients' powers of categorisation and clinical classification. In fact the experiment was remarkably crude in conception and was designed as an alternative to monthly questioning. As the results came in an attempt was made to correlate the "degree of illness" of the patients as a group in Greater London with meteorological factors and with pollution (smoke and SO_2) measured on the roof of St. Bartholomew's Hospital. The "degree of illness" of the group has been calculated after allotting a "score" to each diary entry as follows:—

$$A = -1$$
$$B = 0$$
$$C = +1$$
$$D = +2$$

$$\text{Then Mean Score} = \frac{\text{Sum of scores for all patients}}{\text{Number of patients}}$$

The mean score provides a measure of the "degree of illness" of the group as a whole, ranging from 0 to 1 in winter and below 0 in summer.

There remains to be done an immense amount of analysis but some preliminary results from 180 patients in Greater London are shown graphically in Fig. 2.

From a preliminary examination it seems that a close correlation exists between "degree of illness" and air pollution (smoke and SO_2); the correlation is closest in mid-winter and ceases to exist by the time spring comes by which time temperature and other factors seem to assume some control; whenever pollution becomes severe, clinical deterioration occurs. These results are not merely a reflection of visibility because the variations in pollution recorded cannot always be detected visually. It might be that certain combinations of conditions are particularly injurious or that "threshold" levels of pollution are required to produce ill-effects, and, if so, the harmful conditions could be quantitative or qualitative variations of "normal" urban pollution and weather. Manifestly, the analysis of these results is in its very early stages; earlier it has been said that individual patients react differently to apparently similar and synchronous conditions and it is hoped that further detailed analysis might reveal some individual consistency of response which will contribute to our better understanding of this problem.

So far the diary experiment has been valuable as a probe technique in that it has indicated the need to give attention to pollution as distinct from fog. Usually wet fog does not seem to have marked ill-effects on patients whereas the diaries showed that a period of sudden high pollution with low relative humidity had a bad effect on the Bart's group on January 19th, 1955 (Figs. 1 and 3, Waller and Lawther, 1955).

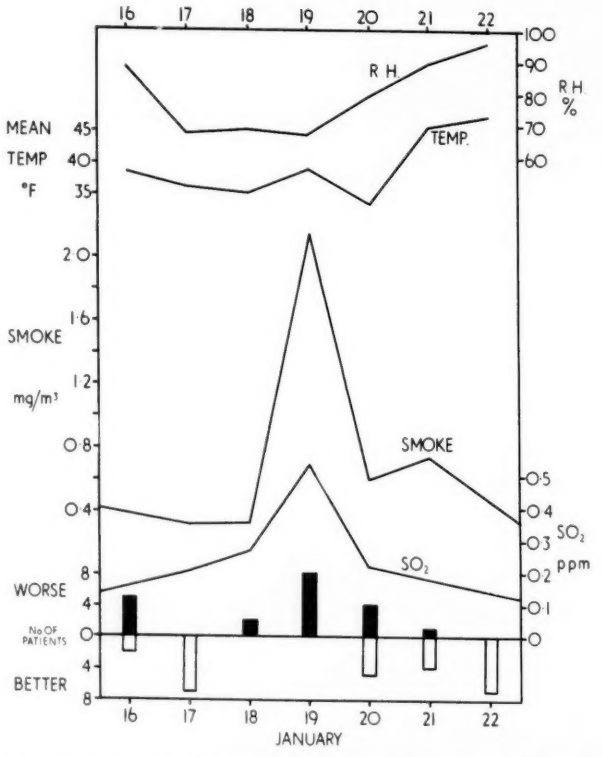

Fig. 3 Graph showing effect on bronchitic patients (Bart's) of high pollution without fog.

We hope that this use of the patient as an instrument for the investigation of air pollution will bear fruit. The crude humble approach must not be scorned because it looks inadequate beside modern complex methods. Frequently the complex methods are designed specially to discover the truth when it is deeply hidden — to distinguish the trees in the wood; but, though some of us stand in awe of Science, we must keep our eyes open wide, even naively, lest we miss seeing the wood before us.

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TETANUS PROPHYLAXIS

(*Continued from page 12*)

(2) When more than two years have elapsed, an emergency booster dose of toxoid may be required.

(3) In cases with wounds most likely to lead to the fulminating type of tetanus proceed as for (1) and (2) but additional protection should be considered in the form of anti-tetanus serum (see above).

NOTE: Complete a signed record card and hand it to the employee for safe keeping. Keep a careful record of all injections (anti-serum, toxoid, etc.) including the date, the correct name of the preparation, the manufacturers number, the dose administered, and reactions if any.

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